Dec. 14, 1965 R. C. BREITHAUPT 3,224,005

DUAL-APERTURE OMNIDIRECTIONAL ANTENNA

Filed March 1, 1963 2 Sheets-Sheet 1

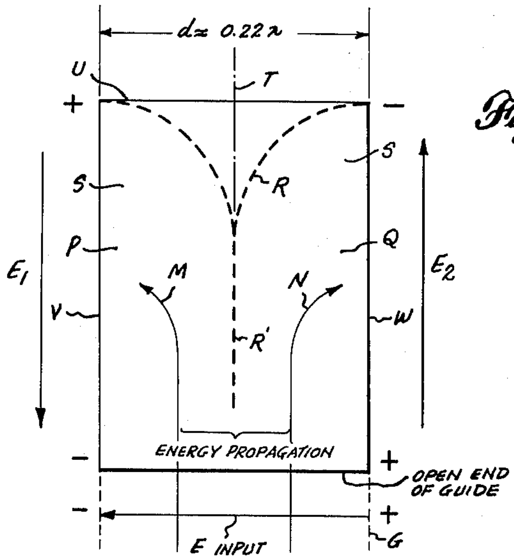

Fig. 1.

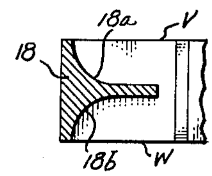

Fig. 4.

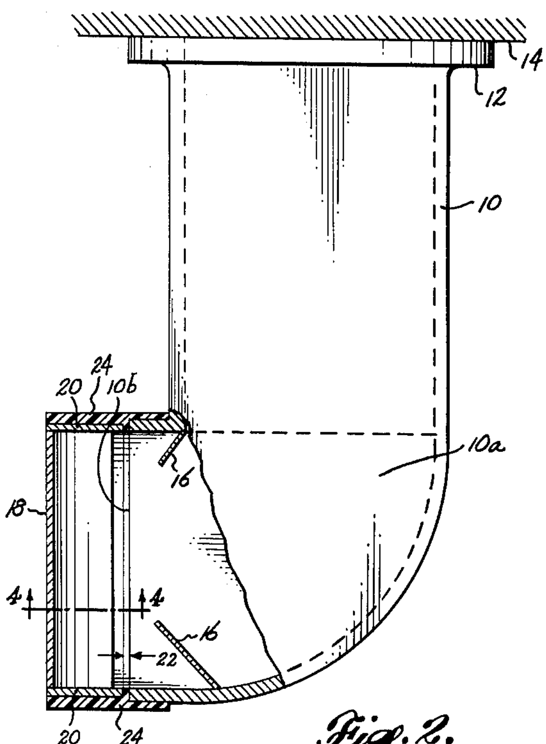

Fig. 2.

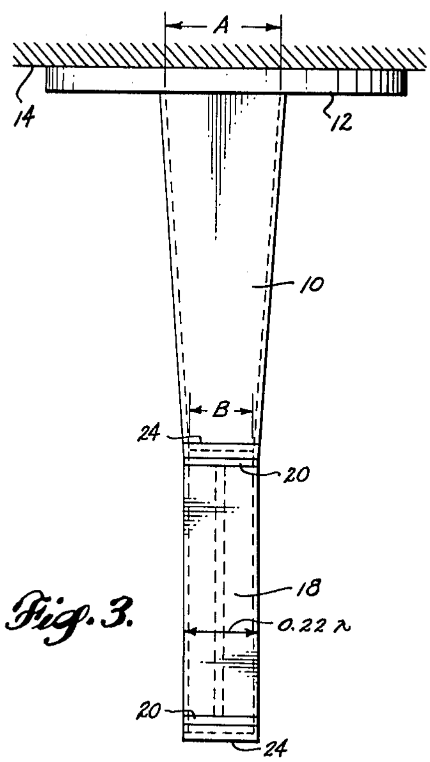

Fig. 3.

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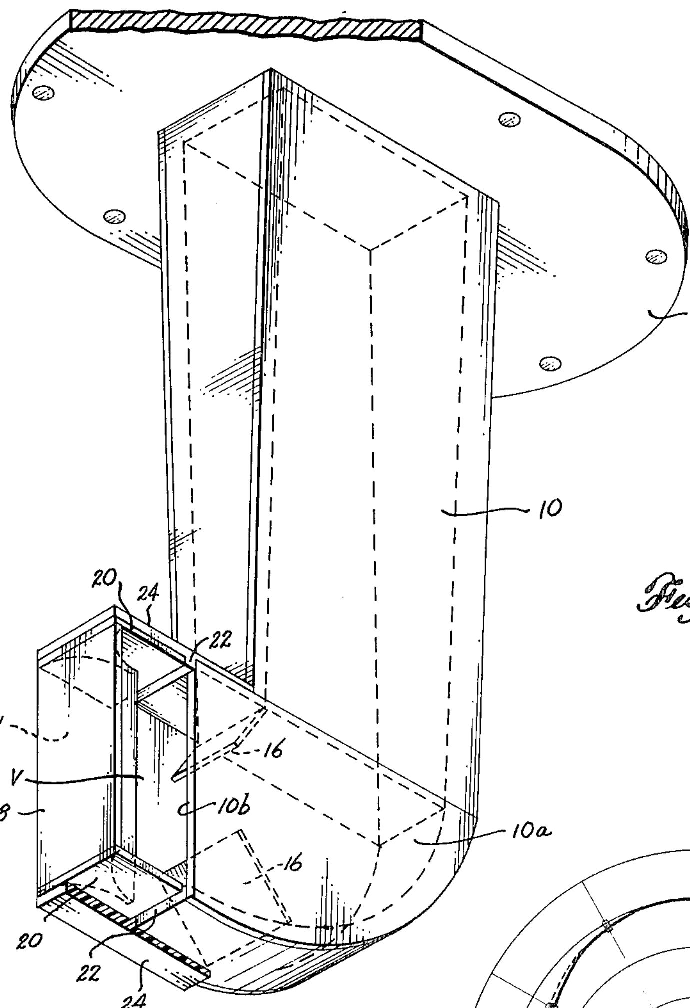

Fig. 5.

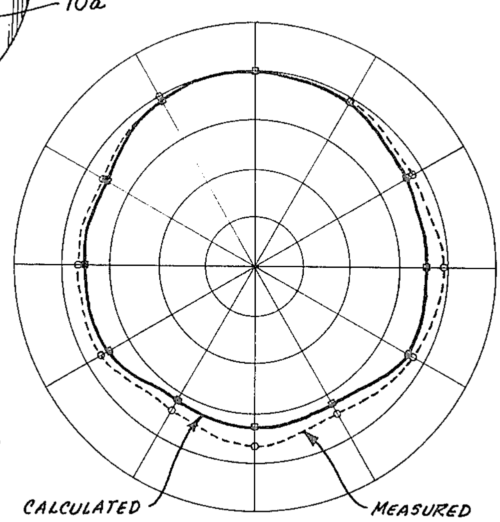

Fig. 6.

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DUAL-APERTURE OMNIDIRECTIONAL ANTENNA

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This invention relates to an improved omnidirectional antenna, and more specifically to one capable of operation at microwave frequencies with polarization oriented in the plane of omnidirectionality. The invention is herein illustratively described by reference to the presently preferred embodiment thereof; however, it will be recognized that certain modifications and changes therein with respect to details may be made without departing from the essential features involved.

A further object of the invention is to devise an antenna particularly adapted for energization by conventional rectangular waveguide feed and possessed of broadband characteristics (i.e. of the order of 40 percent where the VSWR of the upper and lower frequencies exceeds a 1.5:1 ratio). A related object is to devise such an antenna which when mounted in depending position beneath a lower surface of an aircraft fuselage or other support, serving as a ground plane, presents an omnidirectional field pattern in an azimuth plane with its major lobe in vertical planes directed at a small angle (such as 10° to 20°) downwardly from the horizontal. Thus oriented, the improved antenna is polarized horizontally.

A further object of the invention is to devise such an antenna system capable of handling relatively high power levels (i.e. in the range above two kilowatts).

A highly important objective is to achieve these attributes in an antenna of simple, inexpensive construction, which is highly compact and which lends itself to pressurization when necessary. Ruggedness and durability are other objectives.

As herein disclosed, the improved antenna comprises a rectangular waveguide section including a vertically disposed supporting portion adapted for connection to an energy source, and H-plane bend of substantially 90 degrees and a horizontally directed open end occurring immediately adjacent the bend. An energy director mounted in alignment with the open end of the waveguide, and cooperating therewith to form dual laterally directed apertures, comprises an energy-splitting and directing conductive wedge received between conductive side plates. The inclined sides of the wedge diverge mutually at a progressively increasing angle to a maximum of approximately 180 degrees in the direction away from the end of the waveguide and in symmetrical relationship to the extended H-plane of the waveguide. The E-plane width of the waveguide at the open end is such that the dual apertures are spaced apart by approximately 0.22 wavelengths.

The director unit is mounted on the waveguide by dielectric supports which establish a short insulative gap distance separating the waveguide and the side plates of the director. Inductive window elements mounted within the open end of the waveguide section cooperate with the dielectric medium bridging the gap distance to impart broadband impedance characteristics to the antenna.

These and other features, objects and advantages of the invention will become more fully evident from the following description by reference thereof to the accompanying drawings.

FIGURE 1 is a diagram illustrating the basic operating principle of the improved antenna.

FIGURE 2 is a side elevation view of the improved antenna installed in depending position on a ground plane surface.

FIGURE 3 is a side elevation view taken at right angles to the view in FIGURE 2.

FIGURE 4 is a sectional view taken on line 4—4 in FIGURE 2.

FIGURE 5 is a perspective view of the improved antenna unit seen from a bottom aspect.

FIGURE 6 is a graph showing computed and measured radiation patterns for the improved antenna.

It will be recognized by the reciprocity theorem that the antenna of this invention is capable of operation both for transmission and for reception of energy. As shown in simplified form as a transmitting device in FIGURE 1, energy propagating in the direction of the arrows M and N with polarization designated by the vector E input passes through the open end of the adjoining feed waveguide G into two cavities P and Q defined by the wedge R and confining side walls S. The wedge is formed by surfaces which diverge oppositely from a common plane T which is coincident with the H-plane of the waveguide G. The wedge surfaces diverge at a progressively increasing angle from a small acute angle, or zero, to an angle of approximating 180° at the base end U of the wede. Preferably a thin partition R′ extends from the apex of the wedge a short distance toward the open end of the waveguide. The resultant side apertures V and W thus formed at the exits of the two cavities P and Q are excited by field vectors E1 and E2 of opposite polarity. These apertures are spaced apart by substantially 0.22 wavelengths at the high end of the operating frequency band. These are the conditions for omnidirectionality of the resultant radiation field emanating compositely from the two oppositely directed apertures V and W.

In the practical example shown in FIGURES 2 through 5 the waveguide section **10** which feeds, physically supports and comprises part of the antenna carries a base flange **12** suitable for connection to a matching flange of an adjoining section of waveguide (not shown) or for mounting the unit on a supporting surface **14**, such as a wing bottom or the belly of an aircraft. Such connection and mounting details are omitted from the drawing since they are or may be conventional. The waveguide **10** is of rectangular cross section and capable of sustaining propagation in the TE_{10} mode, wherein the E-vector is oriented perpendicular to the broad walls of the waveguide. The H-plane of the guide is defined as the longitudinal midplane parallel to the broad walls, and the E-plane is defined as the longitudinal midplane perpendicular to the broad walls of the waveguide.

With the waveguide section **10** mounted in vertically depending position from a horizontal conductive surface **14** the antenna exhibits an omnidirectional radiation pattern in azimuth. Minimum interference from the waveguide is achieved by forming an H-plane bend **10**_a_ therein immediately adjacent to its open end **10**_b_. Inductive partitions **16** located immediately inside the open end **10**_b_ form an inductive impedance-matching window in the guide according to well-known principles of impedance matching.

As shown best in FIGURE 3, the waveguide width in the E-plane tapers from a width A at its base end, optimum for energy transmission in the TE_{10} mode, to a width B which is of the order of a quarter wavelength (i.e. optimized at substantially 0.22 wavelengths) for purposes of establishing proper spacing between the antenna apertures.

The energy director unit comprises the wedge **18** having mutually divergent surfaces **18**_a_ and **18**_b_ received between conductive side walls **20** which extend in substantial alignment with the narrow walls of the open-end portion of the waveguide section **10**. These side walls have a width approximating equal to the width of the narrow walls of the waveguide section (i.e. 0.22 wavelengths) and a length equal to or slightly exceeding the length of the wedge measured in the direction of propagation along the axis of the open end portion of the waveguide section. The thickness of the wedge at its minimum is a small fraction of the E-plane interior width of the waveguide section whereas the maximum thickness of the wedge at its opposite, base end corresponds approximating to the E-plane thickness of the waveguide section. As previously stated, the conductive divergent surfaces of the wedge, by which the energy emanating from the waveguide section is equally divided and turned through a right angle in each of opposite directions, in the E-plane, diverge increasingly from a very small acute angle or zero at the apical end of the wedge to an angle of approximating 180°. A short insulating gap distance **22** is established between the waveguide end **10***b* and the adjacent edges of the confining side walls **20** of the energy director by the supporting two plates **24** of dielectric material suitably joined by screws, adhesive, or other means (not shown) to the energy director side plates and to the adjacent walls of the waveguide section.

If desired, the dual apertures (V and W) may be covered over and sealed by dielectric windows so as to permit pressurization within the antenna and waveguide unit.

Impedance match or compensation in order to achieve broadband operation characteristics is achieved in the improved antenna unit by taking into consideration sevtral factors including the following: the characteristic impedance of the open-end waveguide itself, the type of material used for the dielectric supporting elements **24**, the gap distance **22**, the precise shape and size of the dual apertures or windows V and W and of the wedge surfaces, and by the size and placement of the inductive curtains or partitions **16**. Typically the gap distance **22** is approximating 0.05 wavelengths at the high frequency end of the band.

In FIGURE 6 the measured radiation pattern in an azimuth plane is shown by comparison with the calculated radiation pattern. It will be noted that the degree of uniformity of the pattern is high. In a vertical plane, the main lobe of the omnidirectional pattern occurs at an angle between 10° and 20° to the ground plane surface **14** in a downward direction.

These and other aspects of the invention will be recognized from the foregoing description and illustration of the preferred embodiment which is intended to illustrate and not delimit the scope hereof.

I claim as my invention:

1. A broadband dual-aperture omnidirectional antenna comprising a section of waveguide operable in the TE_{10} mode and having an open end at which the interior width of the guide in the E-plane thereof is approximately one quarter wavelength at the high-frequency end of the band, director means forming a pair of conductive surfaces diverging mutually in relation to a common plane therebetween from a minimum spacing representing a small fraction of the guide's E-plane interior width to a maximum spacing substantially equal to said E-plane interior width, said conductive surfaces having a width at least substantially equal to the guide's H-plane interior width, and means mounting said director means in alignment with the open end of the waveguide section and with its common plane substantially coincident with the H-plane of the waveguide, the angle of divergence between said surfaces increasing progressively from a small acute angle adjacent the point of minimum spacing therebetween to and terminating at an angle approximating 180° at the point of maximum spacing therebetween.

2. The antenna defined in claim **1**, wherein the waveguide is of rectangular cross section and wherein the director means further includes conductive plates extending substantially in alignment with the side walls of the waveguide which are parallel to the E-plane thereof, said plates being spaced from the end of the waveguide by a gap distance and electrically insulated therefrom, said conductive plates extending oppositely from the common plane and transversely beyond the respective mutually divergent surfaces.

3. The antenna defined in claim **2**, wherein the waveguide section includes an H-plane bend of approximately 90° therein immedately adjacent the open end thereof, whereby the omnidirectionality of the radiation pattern of the antenna lies in a plane substantially at right angles to the remaining portion of waveguide.

4. The antenna defined in claim **3**, including dielectric support members interconnecting the director means and the waveguide section and having a bridging portion extending across said gap distance, and further including impedance-matching inductive window elements mounted in the waveguide section adjacent the open end thereof.

5. The antenna defined in claim **4**, wherein the waveguide includes a portion the width of which in the E-plane thereof tapers in the direction of energy propagation, and wherein the waveguide width in said plane is approximately 0.22 wavelengths at the location of the open end.

6. A broadband dual-aperture omnidirectional antenna comprising a section of rectangular waveguide tapering in width in the E-plane toward one end thereof to a width of approximately 0.22 wavelengths and undergoing an H-plane bend through approximately 90° at such open end, and a conductive wedge disposed across such open end to divide energy emanating from said open end in two divergent paths, said wedge having a leading edge coincident with the H-plane of the waveguide and having a taper angle which increases progressively therefrom to its opposite end, the thickness of the wedge at such opposite end approximating the thickness of the waveguide in its E-plane.

7. The antenna defined in claim **6**, wherein the taper angle of the wedge increases from a small acute angle adjacent its leading edge to approximately 180° at its opposite end.

8. The antenna defined in claim **7**, further including conductive side plates adjacent opposite sides of the wedge and disposed in approximate alignment with the respective side walls of the waveguide parallel to the E-plane thereof at the open end of such waveguide.

9. The antenna defined in claim **8**, wherein said conductive plates are electrically separated from the end of the waveguide section by a gap distance and are supported in relation to the waveguide by dielectric members bridging said gap distance.

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